# MONTHLY WEATHER REVIEW.

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BOARD OF EDITORS { Mr. Horace E. Smith, Chief Clerk Weather Bureau, Professors Henry A. Hazen, Thomas Russell, and Charles F. Marvin, and Mr. Edward B. Garriott, in charge of Review Room.

## INTRODUCTION.

This REVIEW is based on reports for December, 1891, from 2,455 regular and voluntary observers. These reports are classified as follows: 159 reports from Weather Bureau stations; 118 reports from United States Army post surgeons; 1,581 monthly reports from state weather service and voluntary observers; 32 reports from Canadian stations; 158 reports through the Central Pacific Railway Company; 407 marine reports through the co-operation of the Hydrographic Office, Navy Department; marine reports through the "New York Herald Weather Service;" monthly reports from local weather services established in all states and territories, except Idaho, and international simultaneous observations. Trustworthy newspaper extracts and special reports have also been used.

## CHARACTERISTICS OF THE WEATHER FOR DECEMBER, 1891.

The month was warmer than usual in districts east of the Rocky Mountains, and from eastern Pennsylvania and eastern New York over New England the mean temperature was the highest ever noted for December. Over the plateau region and along the Pacific coast the mean temperature was below the normal, and at stations in the middle and southern plateau regions and on the middle and south Pacific coasts the month was the coldest December on record. The principal cold wave of the month appeared on the north Pacific coast on the 24th, and reached the Atlantic coast the night of the 26th. The temperature fell below freezing on the Pacific slope, except at points along the immediate coast, and was below —20° in the Red River of the North Valley. The line of zero temperature extended from central New Mexico to Upper Michigan, and the line of freezing weather reached the Gulf coast and northern Florida. The minimum temperatures attending this cold wave were the lowest ever recorded for December over the southwestern districts, and tender vegetation, oranges, and nursery stock were injured in southern California and Arizona.

### PRECIPITATION.

The monthly precipitation was in excess of the December average from the north Pacific coast to the west Gulf states, from the southeast slope of the Rocky Mountains to the Lake Superior region, and from Mississippi northeastward over New York and southern New England, the greatest excess being noted on the north Pacific coast, where it was 4.00 to 6.00 inches. Over the north-central districts, west of the Lake region, in extreme southwest, southeast, and northeast parts of the country, and from the middle Mississippi valley to eastern Ontario the monthly precipitation was deficient, the most marked deficiency appearing on the south Atlantic and south Pacific coasts, where it was more than 2.00 inches. At points in northwest Washington, west Oregon, north Kansas, north Iowa, southeast Minnesota, and central Pennsylvania the monthly precipitation was the greatest on record for December, and at Fort Assinaboine, Mont., the amount, 0.08 inch., corresponded with the least December precipitation, noted in 1881. More than 100 inches of snow fell at stations on the line of the Central Pacific Railroad crossing the summit of the Sierra Nevada Mountains, and the monthly snowfall was slightly less than that amount in the mountains of Colorado. Over the eastern part of the country the snowfall was very deficient, and in New England and the middle Atlantic states the amount was insufficient to afford protection to grass and grain.

### STORMS.

The storms of the north Atlantic Ocean were generally of slight intensity over the western part of the ocean, but developed great energy after leaving American waters. The most destructive of these storms visited the British Isles between the 6th and 12th, causing loss of life and much damage to property and shipping. A remarkable succession of cyclonic areas from the north Pacific Ocean caused unusually stormy weather on the north Pacific coast, and during the latter part of the month the storms which visited that region were notably persistent and severe. On the 3d destructive storms occurred from the north-central districts to the Gulf States, and on the 4th stormy weather was general from the Mississippi Valley to the Atlantic coast. The latter part of the month was marked by storms of considerable energy in all districts, save along the middle and south Pacific coasts.

### INLAND NAVIGATION.

Navigation closed at a number of ports on the Great Lakes and on the Erie Canal, and the rivers in the northern tier of states were generally frozen.

## ATMOSPHERIC PRESSURE (expressed in inches and hundredths).

The distribution of mean atmospheric pressure for December, 1891, as determined from observations taken daily at 8 a. m. and 8 p. m. (75th meridian time), is shown on Chart II by isobars.

In December the pressure is usually highest over the middle plateau region and in an area covering eastern Tennessee and adjoining parts of the Carolinas and Georgia, where it is above 30.20, and is lowest over the Gulf of Saint Lawrence,

where it is below 29.95. From the extreme northeastern and northwestern parts of the country the barometric gradient is marked to the Iceland and Bering Sea areas of low pressure, where the normal values are below 29.50 and 29.60, respectively. The pressure increases over the United States, except from the middle plateau region to the north Pacific coast, the most marked increase being shown in the Red River of the North Valley, where it exceeds .05. A marked increase of pressure occurs over the west part of the north Atlantic Ocean between the West Indies and Bermuda, while from the 35th parallel to Iceland and southern Greenland the pressure is generally lower than in November, the decrease in the Iceland low area being more than .20.

In December, 1891, the mean pressure was highest in the south Atlantic coast states and thence over eastern Tennessee and northeastern Alabama, where it was above 30.25, the highest mean reading, 30.31, being noted at Augusta, Ga. In districts south of the Ohio River and east of the Mississippi River, and in an area extending from the Pacific coast between the 35th and 40th parallels over Nevada, Utah, and western Colorado, the mean pressure was above 30.20. The lowest mean pressure was noted from the Pacific coast north of the 48th parallel over the British Northwest Territory, where it was below 29.85, and the mean values were below 29.90 along the northern border of the country from the Lake Superior region westward.

As shown by Chart IV, the ridge of high pressure over the southern part of the country from the Atlantic to the Pacific oceans, which appears on Chart II, marks the path of the high pressure areas of the month, the high area of the middle plateau region and the Pacific coast indicating the point of entrance and region of slow movement over the western part of the continent, and the high area of the south Atlantic states showing where the high areas from the west united with the western extremity of the Atlantic Ocean high area and drifted slowly eastward. Chart I shows that the region of exceptionally low pressure from the north Pacific coast over the British Northwest Territory embraces the tracks of an unusual number of storms of great intensity which advanced from the Pacific Ocean.

A comparison of the pressure chart for December, 1891, with that of the preceding month shows an increase of pressure over the southeastern and southwestern parts of the country, and a marked decrease over the northern and central sections. The greatest increase of mean pressure occurred at stations in the south Atlantic states, on the middle and south Pacific coasts, and over Arizona, where it was .10 or more, and the most marked decrease was noted along the northern border of the country and in the north-central valleys, where it exceeded .15. The plateau region area of high pressure occupied a more southern position than for November, 1891, and an increase of about .05 occurred within its limits, and the south Atlantic coast high area extended westward, with an increase of .05 to .10. In each of the months referred to the pressure was lowest along the northern border of the country, the mean values being .05 to .10 lower in December.

The mean pressure was above the normal in the Atlantic coast states, and from the lower lake region to the Gulf coast; it was also above the normal on the middle and south Pacific coasts and over the western parts of the middle and southern plateau regions. The pressure was below the normal from the Mississippi and Ohio valleys and the lower lake region westward to the Rocky Mountains, over the northern plateau region, and on the Pacific coast north of the 43d parallel. The greatest departure above the normal occurred on the Atlantic coast between the 32d and 39th parallels and on the middle California coast, where it exceeded .10, and the most marked departure below the normal was noted in the Red River of the North Valley, and from north-central Montana over Alberta, where it was more than .25.

## HIGH AND LOW AREAS.

The paths of areas of high and low pressure over the United States and Canada during December, 1891, are shown on Charts IV and I, respectively, and some of the more notable features of the areas are given in the table at the end of this chapter.

### HIGH AREAS.

Twelve high areas appeared, the average number traced for December during the last 17 years being 8. Of the high areas traced for the current month one was a continuation of high area VIII for November, 1891; one advanced northeastward from the Gulf of Mexico; one moved eastward from the middle plateau region; four appeared in the British Possessions; and five were first located off the Pacific coast between the 35th and 45th parallels. Two of the Pacific areas traversed the continent, the average velocity being 36 miles per hour, and one, number XI, was central over northern New York at the close of the month. The course of the high areas was east-southeast to southeast to the Gulf and Atlantic coast states, and thence northeastward to Nova Scotia, where the tracks appeared to recurve to the eastward, and the average rate of advance, 28 miles per hour, was about the same as the average velocity of high areas for December. The following is a description of the high areas traced:

I.—November closed with an area of high pressure central over western Virginia and temperature below freezing in the east Gulf states and along the Atlantic coast north of Florida. The morning of December 1st this high area was central near Augusta, Ga., with pressure 30.60; the temperature was below freezing to the east Gulf coast and northern Florida, and heavy frost was reported in the north part of the Florida Peninsula. By the 2d the center had passed off the Carolina coast. Moving slowly north-northeast the high area was central off the New England coast the evening of the 3d, whence it recurved eastward over Nova Scotia by the morning of the 4th.

II.—The presence of this high area off the north California coast was indicated by evening reports of the 1st, and at 8 p. m. of the 2d it was apparently central over extreme southwest Oregon, with pressure above 30.30, and temperature below freezing over the west part of the middle plateau region. During the 3d the center moved southeastward over Nevada and Utah, with an appreciable decrease of pressure, temperature below freezing over New Mexico and east Arizona, and snow from western Nevada to north New Mexico. During the 4th the center moved eastward along the Gulf coast, the line of freezing weather extended south of El Paso, Tex., and snow fell in the east part of the middle plateau region. On the 5th the center remained nearly stationary over South Carolina, where a slight increase of pressure was shown, and by the morning of the 6th it had disappeared off the Carolina coast.

III.—The presence of this high area off the middle Pacific coast was shown by evening reports of the 4th. By the morning of the 5th the pressure had risen above 30.30 over northern California and western Oregon, and the evening of that date a reading of 30.50 was noted at Roseburgh, Oregon. During the 6th the high area occupied the west part of the middle plateau region, the pressure rose above 30.80 at Winnemucca, Nev., the temperature was below freezing over the east part of the southern plateau region and on the southeast slope of the Rocky Mountains, and there was an abnormal fall in temperature of more than 20° in 12 hours from southern Missouri to northern and eastern Texas. During the 7th this area remained nearly stationary over Utah and western Colorado, with pressure above 30.80 in the morning; the temperature continued below freezing over New Mexico and in the north part of the west Gulf states; there was a decided fall in temperature east of the Mississippi River and south of the Lake region, the abnormal fall in 12 hours exceeding 20° in the Atlantic coast states from northern Virginia to Florida; and the lowest temperature of the month was noted at Los Angeles, Cal., Santa Fé, N. Mex., and Abilene and Galveston, Tex. By the morning of the 8th the center had shifted position to the west Gulf and the evening of that date was central near

Augusta, Ga., with pressure above 30.60, and during the 9th it passed eastward off the coast.

During the presence of this high area over the middle plateau region an increase of pressure of about .30 was shown; during the 6th and 7th its advance movement was slow, about 14 miles per hour; and one of the most important cold waves of the month extended over the southwest and southern districts from the 5th to 8th, carrying the line of freezing weather almost to the immediate Gulf coast by the morning of the 8th, and causing heavy frost in northern Florida.

IV.—The presence of this high area off the middle Pacific coast was shown by evening reports of the 9th. The morning of the 10th the pressure rose above 30.50 over western Oregon, and the evening of that date the center was over northeastern Oregon, with pressure above 30.70. The temperature fell 10° to 20° in 12 hours over the middle and east parts of the plateau region, and freezing weather extended southward over the east part of the plateau region into Mexico. From the 11th to 15th, inclusive, this high area remained nearly stationary over the middle plateau region. A gradual decrease of pressure occurred, followed on the 14th by an increase. During the 16th the area moved southeastward, and by the morning of the 17th had apparently merged into high area VII which extended from the Lake Superior region southwestward.

V.—Was apparently an offshoot of high area IV, and on the 11th was central over Nebraska, with pressure above 30.70. During the 12th the center moved east-southeast over the Ohio Valley, with a slight decrease of pressure and an abnormal temperature fall of 5° to 10° in 12 hours from the lower Missouri valley to the middle Atlantic coast. During the 13th the area settled southward over the south Atlantic states, with a marked decrease of pressure, and the temperature fell below freezing from the upper Ohio valley over western Virginia. By the morning of the 14th the center had passed off the south Atlantic coast.

VI.—Appeared north of the Lake region the morning of the 14th, with pressure above 30.30 and an abnormal temperature fall of 5° to 17° in 12 hours from the lower lakes over the Saint Lawrence Valley and the Canadian Maritime Provinces. Moving southeastward, with a slight increase of pressure, the center passed off the New England coast during the 15th.

VII.—Appeared in the Saskatchewan Valley the evening of the 15th, with pressure above 30.40, and a temperature fall of 10° to 20° in 12 hours from Manitoba to the middle Mississippi and lower Ohio valleys. During the 16th the center advanced to Minnesota and a marked fall in temperature occurred to the Atlantic coast. The 12-hour change was more than 20° in New England, and at points in the lower lake region the 24-hour change exceeded 30°. The temperature fell below zero in the Red River of the North Valley and northern Ontario, and the line of freezing weather extended over the north part of the Ohio Valley. During the 17th the area was central over the upper lake region, with pressure above 30.50; the temperature fall was 5° to 15° in 12 hours, and 20° to 30° in 24 hours at points along the Atlantic coast north of the Carolinas; the line of freezing weather extended southward to the Ohio River and Virginia; and the lowest temperature of the month was noted from the east part of the Lake region over middle and northern New England. Passing southeastward the center reached northern Virginia the evening of the 18th; the pressure rose above 30.60; the 24-hour temperature fall was more than 10° in the Atlantic coast states between the 32d and 40th parallels; the line of freezing weather extended to South Carolina, Tennessee, and Arkansas; and the lowest temperature of the month occurred from the middle Ohio valley eastward to the Atlantic coast between the 38th and 41st parallels. During the 19th the center passed to southeastern New York, with a decrease of pressure, and generally higher temperature over the eastern part of the country, save in the Saint Lawrence Valley. During the 20th it moved northeastward over New England, and thence eastward over Nova Scotia, with a slight increase of central pressure by 8 p. m.

VIII.—The presence of this high area off the middle Pacific coast was indicated by reports of the 20th and 21st; by the morning of the 22d the center had reached the middle plateau region, with pressure above 30.50, and by 8 p. m. the area was central over Utah. On the 21st the 12-hour temperature fall was more than 10° over the west part of the middle plateau region, the 24-hour fall was 20° in Alberta, and freezing weather occurred over the plateau region to the Mexican border. During the 22d the temperature fell 20° in western Colorado, and a reading of 2° was recorded at Montrose, Colo. During the 23d this high area settled southward and was apparently dissipated by a decrease of pressure over the Colorado Valley and southern California.

IX.—Appeared over Alberta the evening of the 23d, and the morning of the 24th the pressure rose to 30.74 at Calgary. A decided fall in temperature occurred west of the Missouri and Red River of the North valleys on the 24th, the abnormal 12-hour change varying from 20° to 30° from Colorado to Manitoba; the temperature was below freezing generally over the plateau region, and west of a line traced from southern New Mexico to the west end of Lake Superior; and the lowest temperature of the month occurred over Washington and Oregon. During the 25th this high area passed southward to Utah, with a slight decrease of pressure; a general fall in temperature occurred between the Mississippi River and the Rocky Mountains and over the southern plateau region, the 12 and 24 hour changes ranging from 20° to over 30° in the western Mississippi valley; the line of freezing weather extended from central Texas to the upper lake region; the lowest temperature of the month was noted throughout the plateau regions; and the lowest temperature ever reported for December during the respective periods of observation was noted at Montrose, Colo., Keeler and San Diego, Cal., and Yuma, Ariz. The high area remained nearly stationary over southern Utah and northern Arizona during the 26th, an appreciable decrease of pressure being shown by the 8 p. m. report; the cold wave extended to the Atlantic coast, with temperature falls of more than 20° from the Mississippi River to the Alleghany Mountains; the line of freezing weather extended from near San Antonio, Tex., to the east part of the Lake region; and the lowest temperature of the month occurred from the Mississippi River to the Rocky Mountains. The 8 a. m. report of the 27th locates the center over New Mexico, and higher pressure over the west part of the Gulf of Mexico indicated the formation of a well-defined high area in that region.

X.—This high area was a continuation of number IX, and is given a separate tracing and description on account of the appearance of two distinct anticyclonic centers within an area of high pressure which extended from the plateau region over the Gulf of Mexico the morning of the 27th, one of which, number IX, occupied New Mexico, and the other, number X, the west Gulf. By the evening report of the 27th one center, only, appeared, with highest pressure over the interior of the south Atlantic states. On this date marked temperature falls occurred in the Atlantic coast states, the 12-hour changes ranging from 10° to over 20°, and an abnormal fall in temperature of 32° in 24 hours was noted at Augusta, Ga.; the line of freezing weather extended from Mobile, Ala., northeastward along the Alleghany Mountain range to southern Pennsylvania, and thence eastward to the coast; and the lowest temperature of the month was recorded at stations in the lower Mississippi valley, in the Ohio Valley, and on the south shore of Lake Erie. During the 28th the center moved rapidly northeastward to the lower Saint Lawrence Valley, where it united with an area of high pressure from the Hudson Bay region, after which it passed southeastward over Nova Scotia during the 29th.

XI.—Advanced eastward over California, and the evening of the 28th was central over southwestern Utah, with pressure above 30.30. A marked fall in temperature occurred over the plateau region on this date, the 12-hour changes exceeding 20° over the east-central part of the middle plateau; and freezing

weather occurred over the plateau region north of the 35th parallel. During the 29th the area moved rapidly eastward to the east Gulf states, with slight changes in central pressure; the area of lower temperature moved eastward over the central valleys, a 12-hour temperature fall of more than 10° being noted from the lower lake region to the Gulf; and the line of freezing weather extended from central Texas to the Lake region. During the 30th the center remained nearly stationary over the south Atlantic states, with an increase of pressure; and during the 31st it moved northeastward and united over northern New York with high area XII.

XII.—Appeared over Manitoba the evening of the 29th, preceded on the 28th by a very decided fall in temperature over the British Northwest Territory, the abnormal fall in 12 hours being 42° at Qu'Appelle. On the 29th the cold wave extended over the Lake region, a 12-hour fall of 21° and a 24-hour temperature fall of 32° being noted at Prince Arthur, Ontario. During the 30th the center moved eastward north of the Lake region, with pressure above 30.50; the cold wave extended over the middle Atlantic and New England states and the Canadian Maritime Provinces; an abnormal 12-hour temperature fall of more than 20° was noted in the middle Saint Lawrence valley; and freezing weather occurred over the interior of the Eastern States to the Carolinas. During the 31st the center settled southward and at the close of the month was central over northern New York, with pressure above 30.60; on this date the 12-hour temperature fall exceeded 20° over eastern New England and western Nova Scotia; the 24-hour temperature fall was 40° at Quebec; and the line of freezing weather extended to South Carolina.

## LOW AREAS.

The low areas of December advance eastward at an average velocity of about 36 miles per hour. West of the 100th meridian they pursue two principal tracks, one from the Pacific coast north of the 50th parallel south of east to the upper lake region, and the other from Vancouver Island southeastward over the middle plateau and the Rocky Mountain region to the lower Missouri valley. Less frequented tracks are traced from the west part of the Gulf of Mexico to the middle Mississippi valley, and along the Atlantic coast line from the Carolinas to the Canadian Maritime Provinces. East of the 100th meridian the tracks converge and unite over the Saint Lawrence Valley, where an average of more than 5 storms are traced, making this the region of greatest storm frequency within the region of observation. The low areas of December average more than 3 in the Lake region, 2 to 3 in the Ohio and middle and upper Mississippi valleys, and 1 to 2 off the middle and south Atlantic coasts, in the Saskatchewan, Missouri, and lower Mississippi valleys, over the middle and northern plateau regions, and on the north Pacific coast. An average of one storm per month traverses the North American continent from the Pacific to the Atlantic coasts in December.

The tracks of 14 low areas are plotted on Chart I for December, 1891, the average number traced for the corresponding month of the last 17 years being 13. Seven of the low areas advanced from the Pacific coast north of the 45th parallel, one was a continuation of low area XIII for November, 1891, 2 advanced from the British Northwest Territory, 3 apparently developed on the eastern slope of the Rocky Mountains south of the 45th parallel, and one first appeared in the lower Rio Grande valley. Four of the Pacific coast low areas, numbers IV, V, XII, and XIII, traversed the continent, the average rate of advance being 40 miles per hour. The low areas which advanced from the Pacific coast north of the 50th parallel were unusually numerous; their passage over the Pacific slope was attended by excessive rainfall in Washington and Oregon; and the tracks east of the Rocky Mountains were, as a rule, confined to the region north of the 50th parallel. The Pacific coast storms of more southern latitudes, and a low area which appeared over Alberta, advanced to the lower Missouri valley, and passed thence northeastward to the Lake region. The low areas traced from the middle and southeast slopes of the Rocky Mountains, and the low area which appeared over the lower Rio Grande valley, also advanced to the Lake region. During the 17th and 18th a depression of small energy passed northeastward over the Florida Peninsula. The following is a description of low areas traced over the United States and Canada:

I.—Was a continuation of low area XIII traced for November, 1891, and at the opening of the month was central over the Saskatchewan Valley, with pressure below 29.40, whence it moved to Manitoba by the evening of the 1st, with rain from the middle and north Pacific coasts over the northern plateau region, rain and snow in the Red River of the North Valley, and high winds from the middle plateau and middle Rocky Mountain regions over the Great Lakes, the highest velocity noted, 57 miles per hour from the southeast, being reported at Chicago, Ill. By the morning of the 2d the center had moved east of Manitoba, and during that date it disappeared north of the Lake region.

II.—The morning of the 2d the pressure was low from Manitoba and the British Northwest Territory to New Mexico and western Texas, and 3 cyclonic centers appeared, one, low area I, east of Manitoba, one north of Montana, and a third over eastern Colorado. The evening report of the 2d locates the center of low area II over northern Kansas, with pressure below 29.40. On this date the abnormal rise in temperature in 12 hours exceeded 10° in areas east of the Rocky Mountains, and the 24-hour increase was more than 20° in areas south of the Ohio Valley; light rain or snow fell from the plateau region over the middle Missouri and Red River of the North valleys; and wind velocities of 30 to 40 miles per hour were noted from Texas to Montana. During the 3d the center passed to the extreme upper Mississippi valley, with pressure below 29.20; a marked rise in temperature occurred east of the Mississippi River, while from the Red River of the North to Texas the 12-hour temperature fall exceeded 20°; at a number of stations in the eastern-central valleys and the upper lake region the maximum temperature was the highest noted for the month, and at La Crosse, Wis., the temperature was the highest ever reported for December; rain fell generally throughout the central valleys and the Gulf and south Atlantic states, and snow over the middle plateau region and in the upper Missouri and Red River of the North valleys; wind velocities of 30 to 40 miles per hour occurred in the central valleys and the Lake region; a velocity of 52 miles per hour from the south was reported at Cairo, Ill.

During the 4th the center moved to the region north of Lake Superior, with pressure falling below 28.90, a reading of 28.84 being noted at Marquette, Mich., at 8 a. m.; the temperature rose in the early part of the day from the east Lake region to the south Atlantic coast, the abnormal 24-hour rise being 30° at Washington, D. C., where the temperature at 8 a. m. was 24° above the normal; the highest temperature of the month was noted at stations in the northeast districts, and the maximum temperature at Buffalo, N. Y., was the highest ever reported for December; during the day a rapid fall in temperature occurred over the eastern part of the country, except from New England over the Canadian Maritime Provinces, the abnormal 12-hour change being more than 20° at stations in the Lake region, Virginia, and South Carolina; rain fell generally east of the Rocky Mountains, followed by clearing weather in the Southwest, and snow fell in the Northwest; wind velocities of 50 to 60 miles per hour occurred over the Lake region, and a velocity of 63 miles per hour from the southeast was noted at Woods Holl, Mass. During the 5th the center of disturbance passed rapidly eastward north of the Lake region and Saint Lawrence Valley, with an apparent decrease of energy; the clearing condition extended eastward to the Atlantic coast; wind velocities of 30 to 40 miles per hour occurred from the Lake region over New England; and at Lexington, Ky., Buffalo, N. Y., and Woods Holl, Mass., the maximum velocity exceeded 50 miles per hour.

III.—Apparently developed over the east part of the southern plateau region during the early part of the 5th, and the evening of that date was central over Indian Territory, with pressure below 29.70; a marked rise in temperature occurred in the lower Mississippi and Ohio valleys; the highest temperature of the month was recorded at Springfield, Mo., and Vicksburg, Miss.; and a decided fall in temperature was noted over the east part of the plateau region, the abnormal change in 12 hours being 32° at El Paso, Tex. No rain attended this low area on the 5th; snow fell in the middle plateau region. Moving rapidly east-northeast the center reached the lower lake region the night of the 6th, with slight pressure changes; the temperature rose 10° to 18° in the east Gulf states and in the Atlantic coast states south of the 40th parallel; the highest temperature of the month was noted from east Tennessee to northern Florida; the 12-hour temperature fall exceeded 20° from Missouri to eastern Texas; rain fell generally east of the middle and southeast slopes of the Rocky Mountains, except along the Atlantic coast; rain and snow occurred in the Lake region and upper Mississippi valley; and winds of 30 to 40 miles per hour were noted in the central valleys and the south part of the Lake region, the highest velocity, 48 miles per hour from the northwest, being recorded at Chicago, Ill. By the evening of the 7th the center had advanced to the vicinity of Cape Breton Island, where the pressure fell below 29.50. On this date rising followed by falling temperature was noted along the Atlantic coast, the 12-hour temperature fall exceeding 20° from Georgia to Maryland; heavy rain fell in the Atlantic coast states, and snow in the Lake region. By the 8th this low area had passed northeast of Newfoundland.

IV.—Advanced from the Pacific coast north of the region of observation to northern Alberta during the 7th, with pressure falling to 28.88 at Edmonton, N. W. T., at 8 p. m. On the 6th a rapid rise in temperature occurred in Alberta, the abnormal 12-hour change being 25° at Calgary; a marked decrease of pressure was noted along the north Pacific coast; and a wind velocity of 52 miles per hour from the south was reported at Fort Canby, Wash. During the 7th the temperature rose 20° to 30° from the middle-eastern slope of the Rocky Mountains over Manitoba and the north Lake Superior region; heavy rain fell from the north Pacific coast over the northern plateau; and the wind exceeded 50 miles per hour at points from the Washington coast to central Montana, the highest velocity, 98 miles per hour from the south, being reported at Fort Canby, Wash. During the 8th the center advanced to the region north of Lake Superior without an apparent loss of energy; the temperature rose 10° to 20° from the upper Mississippi valley over the Lake region and Saint Lawrence Valley; the highest temperature of the month was noted in the Red River of the North Valley; wind velocities of 30 to 40 miles per hour occurred from the Missouri Valley over the Lake region, and a maximum velocity of more than 50 miles per hour was reported at Chicago, Ill., and Fort Assinaboine, Mont. On this date there was a general absence of precipitation within the region covered by this low area. By the evening of the 9th the center of disturbance had advanced north of the Gulf of Saint Lawrence, unattended by general rain; high winds prevailed from the Lake region eastward, and a velocity of 51 miles per hour from the southwest was reported at Woods Holl, Mass. This low area traversed the north Atlantic Ocean, and its history subsequent to the 9th is given under "North Atlantic storms."

V.—Followed closely after number IV and reached the Saskatchewan Valley the morning of the 9th, with pressure below 29.40, whence it advanced rapidly eastward and the evening of that date was central north of Lake Superior. Rain continued on the north Pacific coast as far south as central California during the 8th, with higher followed by falling temperature north of the 40th parallel. On the 9th light rain or snow fell in areas from the middle and north Pacific coasts to the Lake region; a marked fall in temperature occurred in the Northwest, the 12-hour change exceeding 20° at Calgary; and high winds, reaching a maximum velocity of 56 miles per hour from the west at Cheyenne, Wyo., prevailed over the north-central districts. By the evening of the 10th the center reached the lower Saint Lawrence valley, with an apparent loss of energy.

On the 10th a trough of relatively low pressure extended from low area V southwestward over the Lake region and the central valleys to the south part of the southern plateau region, and the evening report indicated the development of a cyclonic area over or south of New Mexico. High area III occupied the south Atlantic coast, with pressure above 30.40, and high area IV advanced over Oregon, with pressure above 30.70. The morning of the 11th high area V, an offshoot from high area IV, was central over Nebraska, the pressure had risen .50 to .70 in 24 hours over the central and north-central districts, and a ridge of high pressure extended from the north Pacific to the south Atlantic coasts. This distribution of pressure prevented the development and advance of the southern plateau low area, and it disappeared by an increase of pressure during the 11th. Owing to the marked barometric gradient from southern Arizona and southern California northward, a heavy windstorm or "norther" prevailed over the west part of the southern plateau region and southern California on the 10th and 11th.

VI.—Apparently advanced from the British Northwest Territory and on the 12th was central over Alberta, with pressure below 29.70, whence it advanced to South Dakota by the evening of the 13th, with rain in the middle Missouri and upper Mississippi valleys, and a decided increase in temperature in the central valleys. During the 14th the center moved southward to Kansas, and with the eastward movement of high area VI from north of the Lake region it moved northeastward to Iowa by the evening of the 14th, with a slight increase of energy. On this date rain fell generally in the central valleys and the Lake region; a marked rise in temperature occurred east of the Mississippi River and south of the Great Lakes; the highest temperature of the month was noted along the middle Mississippi river; and the temperature fell 10° to 20° in 12 hours from the west Gulf states to the middle Missouri valley. During the 15th the center advanced over the Lake region, with pressure below 29.50; rain fell generally east of the Mississippi River, the rainfall being excessive at points in the east Gulf states; and higher followed by lower temperature was noted from the west part of the Lake region to the east Gulf coast. During the 16th the center advanced to the Gulf of Saint Lawrence, where the pressure fell to 28.88 at Sydney, C. B. I., and at Eastport, Me., the 12-hour decrease of pressure was .94; the clearing condition extended to the Atlantic coast, with 12-hour temperature falls of 10° to 20° in the Atlantic coast states and the Lake region; and wind velocities of 40 to 60 miles per hour occurred along the New Jersey and New England coasts. By the 17th the center had passed north of the Banks of Newfoundland.

VII.—During the 12th two low areas apparently advanced from the British Northwest Territory, one, number VI, passing southward, and the other, number VII, moving eastward to the Lake Superior region, where it was located the evening of that date, whence it moved rapidly eastward to the region north of the Gulf of Saint Lawrence by the evening of the 13th, and advanced thence north of Newfoundland. With the exception of high winds over the lower lakes on the 12th, the passage of this low area was unattended by noteworthy features.

VIII.—Apparently moved from the Pacific coast north of Vancouver Island to Alberta during the 16th, with pressure below 29.50; rain on the middle and north Pacific coasts; and winds exceeding 50 miles per hour on the Washington coast. During the 17th this low area apparently dissipated in the Saskatchewan Valley in the rear of high area VII, which occupied the north-central part of the country on that date.

IX.—Apparently moved eastward north of Washington during the 18th, with central pressure below 29.70, rain along the Pacific coast north of the 40th parallel, and high winds on the Washington coast. During the 19th the center occupied the

Saskatchewan Valley, with pressure below 29.50, rain along the Pacific coast, rain and snow over the middle and northern plateau regions, an increase in temperature east of the 115th meridian, a decrease in temperature of 5° to 10° in 12 hours along the Pacific coast and over the west part of the plateau region, and fresh to high winds from the north Pacific coast to the upper lake region. During the 20th the pressure change in 12 hours was more than .30 over the north part of the northern plateau region, and the approach of a cyclonic area from the Pacific coast north of the region of observation was indicated. This low area apparently united with low area IX which had remained nearly stationary over Alberta. Rain and snow fell over the middle plateau and northern Rocky Mountain regions, and on the Pacific coast rain was followed by clearing weather in the southern districts; high winds occurred on the north Pacific coast, a velocity of 62 miles per hour from the west being noted at Tatoosh Island, Wash. The morning of the 21st a trough of low pressure extended from Manitoba to the Rio Grande Valley with two cyclonic centers, one, low area IX, in Manitoba, and the other, low area X, in Nebraska. By the evening report the two centers had united over Iowa.

X.—With the union of this low area and low area IX cloudy and rainy weather prevailed from the Gulf of Mexico northward, the precipitation being in the form of snow in the more northern districts; at the 8 p. m. report of the 21st the pressure fell below 29.50; fresh gales had been noted in the north part of the central valleys and the western Lake region; the temperature had risen decidedly from the middle and upper Mississippi River to the Alleghany Mountains, and a marked fall in temperature had occurred from Manitoba to the Rio Grande Valley. During the 22d the center passed to the southern Hudson Bay region, without an apparent loss of energy, after which it advanced rapidly eastward and passed off the Labrador coast during the 23d.

XI.—On the 21st a trough of low pressure extended over the central valleys from Manitoba and the Lake Superior region to the Rio Grande Valley. By the evening of the 22d the approach of high area VIII from the Pacific coast caused a marked increase of pressure over the central districts, and a ridge of comparatively high pressure extending from the middle plateau region to the middle Atlantic coast separated low area X, which was central in the Hudson Bay region, and low area XI, which had appeared in the Rio Grande Valley. A third low area, number XIII, appeared on the north Pacific coast. The early history of low area XI was, in many respects, similar to that of the remarkable low area of November 21st–24th, 1891, and the causes which seemed to contribute to its dissolution are, therefore, of interest. With its appearance in the lower Rio Grande valley general rain and temperature above the normal prevailed over the greater part of the central valleys and the Lake region. The morning of the 23d it was central over eastern Texas, with pressure below 29.80, and a trough of low pressure extended thence northeastward to the Saint Lawrence Valley. By the evening report the center had advanced to northern Mississippi, where the pressure fell below 29.60, the lowest pressure noted during its course.

The morning report of the 23d shows temperature considerably above the normal over the east Gulf and Atlantic states, while from the Lake region to Texas there had been a decided fall in temperature. During that date the wave of lower temperature extended eastward to the Alleghany Mountains; heavy rain fell about the center, with clearing weather from the Lake region to Texas. The forces necessary to the further development of energy were in part withdrawn by two areas of low pressure which dominated the weather conditions over the northern districts, one of which, low area X, occupied the Gulf of Saint Lawrence region, and the other, low area XII, the upper Missouri valley. The morning report of the 24th showed a diminution of energy on the part of number XI and an increase of strength in number XII, the latter being central over Kansas, and by the evening report an area of high pressure had advanced from the Hudson Bay region over the Canadian Maritime Provinces, with an increase of pressure of more than .40 in 12 hours over the Gulf of Saint Lawrence. With high pressure occupying its line of advance, and low areas of greater strength absorbing its energy, this low area dissipated south of the lower lake region during the night of the 24th.

XII.—Appeared on the north Pacific coast on the 22d, with pressure below 29.50, heavy rain, and wind velocities exceeding 50 miles per hour on the Washington coast. By the 23d the center had advanced to the upper Missouri valley, with a slight loss of energy; high west winds occurred on the north Pacific coast, and the rain area extended over California to the 35th parallel, and thence over the plateau region to the northeast slope of the Rocky Mountains, with snow from the middle plateau region northward. During the 24th the center moved to the lower Missouri valley, and the evening report showed a secondary low area of considerable strength over western Texas, whence it apparently advanced rapidly northeastward and united with number XII in the Lake region by the morning of the 25th. The evening of the 25th the center occupied upper Michigan, with pressure below 29.50; rain had fallen in the central districts and the Lake region, and snow in the more northern districts to the westward of the storm-center. The temperature fall following this low area and preceding high area IX was very marked, the 12-hour change exceeding 30° from Minnesota to Arkansas. During the 26th the center moved eastward to the lower Saint Lawrence valley, with a decided increase of energy; the pressure fell to 29.12 at Father Point, Quebec, and there was a decrease of .66 in 12 hours at that place; rain, followed by clearing weather, prevailed south of the Lake region, and snow and rain were general in the Lake region; the cold wave extended to the Alleghany Mountains; and gales prevailed over the Great Lakes, a velocity of 66 miles per hour from the southwest being noted at Buffalo, N. Y. The morning report of the 27th showed pressure 28.90 at Father Point, Quebec, and decidedly colder, clearing weather in the Atlantic coast states. By the evening report the center had passed north of Newfoundland.

XIII.—The approach of this low area toward the Pacific coast north of the 50th parallel was shown by reports of the 25th, and by the evening of the 26th it was central near Vancouver Island, with pressure 29.10 at Port Angeles, Wash. On this date rain fell on the middle and north Pacific coasts, and thence over the middle and northern plateau regions, and snow in the upper Sacramento valley; heavy gales prevailed on the north Pacific coast, a velocity of 88 miles per hour from the south being recorded at Fort Canby, Wash. During the 27th the center advanced to the Saskatchewan Valley, without an apparent loss of energy; rain fell from the south Pacific coast over the plateau region to the upper Missouri valley, and snow in Montana and the British Northwest Territory; the temperature rose decidedly from the Lake region and middle Mississippi valley to the middle Missouri valley; a cold wave overspread the districts lying between the middle and northern Pacific coasts and the northeast slope of the Rocky Mountains; and wind velocities of 50 to 60 miles per hour occurred from the middle plateau region to the upper Missouri valley.

During the 28th the center of disturbance advanced to the region north of Lake Superior; the temperature rose 10° to 20° from the Lake region to the Gulf of Mexico, and fell 20° to 40° in 12 hours in the British Northwest Territory; the rain area did not advance east of the Mississippi River; high winds prevailed over the Lake region, a velocity of 56 miles per hour from the southwest being noted at Chicago, Ill. During the 29th the center advanced to the upper Saint Lawrence valley, skirting the west quadrant of high area X which occupied the Canadian Maritime Provinces. A marked decrease of energy was shown on this date; the rain area extended to the Atlantic coast, and the cold wave advanced to the Alleghany Mountains. During the 30th this low area increased in energy

and moved to the south New England coast and thence to western Nova Scotia; clearing weather occurred in the Atlantic coast states; falling followed by rising temperature was noted from the Lake region and Mississippi River eastward; and wind velocities exceeding 50 miles per hour were recorded at points along the Atlantic coast north of the Carolinas. By the 31st the center had passed over the Gulf of Saint Lawrence.

XIV and XIV*a*.—Number XIV was central off the northwestern coast of Washington the morning of the 29th, with pressure below 29.00, heavy gales reaching a velocity of 85 miles per hour from the west at Fort Canby, Wash., and heavy rain on the Pacific coast north of the 35th parallel. By the evening report the center had advanced to the region north of Montana, with an apparent loss of strength, and by the morning of the 30th had moved to the upper Missouri valley, after which it apparently united with XIV*a*, which appeared over the middle plateau region the morning of that date. Low area XIV*a* moved eastward to the vicinity of Salt Lake City, Utah, by the evening of the 30th, without evidence of marked energy, whence it passed to Indian Territory by the close of the month, when a trough of low pressure extended from the western Lake region to Texas, with marked barometric gradients to the east and west. A notable feature of these low areas was the exceptionally heavy snowfall over the middle plateau region during the 29th and 30th.

On the last day of the month a low area of considerable energy was central off the north Pacific coast, where the pressure fell below 29.60, and high winds reaching a velocity of 72 miles per hour from the southeast at Fort Canby, Wash., were noted. On this date an area of high pressure advanced from the Pacific Ocean over California to the middle plateau region; snow fell in the Sacramento Valley, and over the middle and northern plateau regions, and rain prevailed along the Pacific coast.

*Tabulated statement showing principal characteristics of areas of high and low pressure.*

| Barometer. | First observed. | | | Last observed. | | Duration. | Velocity per hour. | Maximum pressure change and maximum abnormal temperature change in twelve hours and maximum wind velocity. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Date. | Lat. N. | Long. W. | Lat. N. | Long. W. | | | Station. | Rise. | Date. | Station. | Fall. | Date. | Station. | Direction. | Miles per hour. | Date. |
| High areas. | | ° | ° | ° | ° | *Days.* | *Miles.* | | *Inch.* | | | ° | | | | | |
| I* | 1 | 34 | 82 | 44 | 64 | 3.0 | 21 | Father Point, Quebec | .28 | 3 | Lynchburgh, Va | 7 | 1 | Key West, Fla. | ne. | 28 | 1 |
| II | 2 | 42 | 124 | 34 | 76 | 3.5 | 36 | Cairo, Ill | .44 | 4 | Palestine, Tex | 24 | 3 | Savannah, Ga. | w. | 36 | 4 |
| III | 5 | 44 | 125 | 35 | 83 | 3.5 | 36 | Abilene, Tex | .46 | 6 | El Paso, Tex | 32 | 5 | Helena, Mont | sw. | 36 | 6 |
| IV† | 10 | 45 | 118 | 37 | 108 | 6.0 | 6 | Tatoosh Island, Wash | .41 | 10 | Pueblo, Colo | 21 | 10 | Helena, Mont | w. | 30 | 10 |
| V | 11 | 42 | 101 | 33 | 81 | 2.5 | 25 | White River, Ont | .42 | 11 | Winnipeg, Man | 20 | 10 | Kitty Hawk, N. C | ne. | 34 | 12 |
| VI | 14 | 50 | 85 | 44 | 68 | 1.0 | 33 | Quebec, Quebec | .38 | 14 | Montreal, Quebec | 17 | 14 | Block Island, R.I. | e. | 38 | 15 |
| VII | 15 | 53 | 104 | 46 | 69 | 4.5 | 24 | Father Point, Quebec | .60 | 17 | Chicago, Ill | 23 | 15 | Kitty Hawk, N. C | n. | 38 | 18 |
| VIII | 22 | 41 | 113 | 35 | 115 | 1.0 | 25 | Salt Lake City, Utah | .32 | 22 | Montrose, Colo | 20 | 22 | Yuma, Ariz | nw. | 24 | 22 |
| IX | 24 | 51 | 114 | 35 | 107 | 3.0 | 20 | Fort Assinaboine, Mont. | .66 | 23 | La Crosse, Wis | 37 | 25 | Pueblo, Colo | w. | 46 | 26 |
| X | 27 | 28 | 92 | 45 | 63 | 2.0 | 49 | Brownsville, Tex | .40 | 26 | Raleigh, N. C | 23 | 27 | Galveston, Tex | nw. | 36 | 26 |
| XI | 28 | 37 | 113 | 44 | 74 | 3.0 | 35 | Pueblo, Colo | .52 | 28 | Winnemucca, Nev | 26 | 27 | Savannah, Ga | nw. | 34 | 30 |
| XII | 29 | 52 | 97 | 44 | 74 | 2.0 | 27 | White River, Ont | .66 | 30 | Qu'Appelle, N. W. T | 42 | 28 | Erie, Pa | se. | 30 | 31 |
| Mean | | | | | | 2.9 | 28 | | .46 | | | 24 | | | | 34 | |
| Low areas. | | | | | | | | | Fall. | | | Rise. | | | | | |
| I‡ | 1 | 52 | 109 | 52 | 93 | 1.0 | 29 | Indianapolis, Ind | .24 | 1 | Shreveport, La | 18 | 1 | Chicago, Ill | se. | 57 | 1 |
| II | 2 | 40 | 103 | 51 | 68 | 3.5 | 24 | Chatham, N. B | .76 | 5 | Concordia, Kans | 17 | 2 | Woods Holl, Mass | se. | 63 | 4 |
| III | 5 | 35 | 98 | 47 | 60 | 2.0 | 50 | Sydney, C. B. I | .52 | 7 | El Paso, Tex | 24 | 4 | Chicago, Ill | nw. | 48 | 6 |
| IV | 7 | 53 | 128 | 51 | 63 | 2.5 | 46 | Swift Current, N. W. T | .54 | 7 | Calgary, N. W. T | 25 | 6 | Fort Canby, Wash | s. | 98 | 7 |
| V | 9 | 54 | 110 | 50 | 67 | 1.5 | 53 | Halifax, N. S | .22 | 10 | Shreveport, La | 16 | 9 | Cheyenne, Wyo | w. | 56 | 9 |
| VI | 12 | 52 | 114 | 48 | 60 | 4.5 | 31 | Eastport, Me | .94 | 16 | Yarmouth, N. S | 23 | 16 | Pueblo, Colo | n. | 60 | 14 |
| VII | 12 | 55 | 106 | 50 | 61 | 1.5 | 56 | Sydney, C. B. I | .30 | 13 | Prince Arthur, Ont | 13 | 12 | Buffalo, N. Y | sw. | 50 | 12 |
| VIII | 16 | 52 | 128 | 53 | 108 | 1.0 | 35 | Edmonton, N. W. T | .40 | 16 | Moorhead, Minn | 14 | 17 | Fort Canby, Wash | se. | 52 | 16 |
| IX | 18 | 51 | 128 | 50 | 97 | 2.5 | 32 | Battleford, N. W. T | .44 | 19 | Pueblo, Colo | 15 | 19 | Tatoosh Island, Wash | w. | 62 | 20 |
| X | 21 | 42 | 99 | 52 | 64 | 2.0 | 41 | Sault de Ste. Marie, Mich. | .36 | 22 | Louisville, Ky | 19 | 21 | Chicago, Ill | sw. | 44 | 22 |
| XI | 22 | 26 | 99 | 38 | 85 | 1.5 | 33 | Parkersburgh, W. Va | .34 | 24 | Little Rock, Ark | 10 | 22 | Vicksburg, Miss | w. | 48 | 23 |
| XII | 22 | 50 | 126 | 51 | 65 | 4.5 | 32 | Father Point, Quebec | .66 | 26 | Saint Vincent, Minn | 25 | 23 | Buffalo, N. Y | sw. | 66 | 26 |
| XIII | 26 | 52 | 128 | 43 | 63 | 4.5 | 31 | Medicine Hat, N. W. T | .72 | 27 | Rockliffe, Ont | 33 | 28 | Fort Canby, Wash | s. | 88 | 26 |
| XIV | 29 | 48 | 127 | 48 | 107 | 1.0 | 40 | Spokane, Wash | .54 | 29 | Medicine Hat, N. W. T | 35 | 29 | Fort Canby, Wash | w. | 85 | 29 |
| XIV*a* | 30 | 42 | 117 | 37 | 98 | 1.5 | 31 | White River, Ont | .54 | 31 | Pueblo, Colo | 25 | 30 | Pueblo, Colo | n. | 42 | 31 |
| Mean | | | | | | 2.3 | 38 | | .51 | | | 21 | | | | 61 | |

*Continuation of high area VIII for November, 1891. †Remained nearly stationary over middle plateau, 11th to 15th, inclusive. ‡Continuation of low area XIII for November, 1891.

## NORTH ATLANTIC STORMS FOR DECEMBER, 1891 (pressure in inches and millimeters; wind-force by Beaufort scale).

The paths of storms that appeared over the west part of the north Atlantic Ocean are shown on Chart I. These paths have been determined from reports of shipmasters received through the co-operation of the Hydrographic Office, Navy Department, and the "New York Herald Weather Service."

In December there is usually an increase of pressure over the north Atlantic Ocean south of the 30th parallel and from the British Isles over the Azores and Cape Verde Islands. Between the Azores and the coast of the United States and thence northward there is a decrease of pressure, the decrease being most marked within the Iceland area of low pressure, where it exceeds .20. The normal distribution of pressure over the north Atlantic in December shows a belt of high pressure stretching across the ocean between the 30th and 40th parallels, with values above 30.10 (764), from which there is a marked gradient to Iceland and southern Greenland, where the pressure falls below 29.50 (749). This distribution of pressure has an apparent effect upon the course of ocean storms; they follow two principal tracks which diverge from the main continental track east of Newfoundland, one running directly into the Iceland low area, and the other skirting its southern quadrants and passing north of the British Isles. The average velocity of north Atlantic storms in December is about 21 miles per hour, and an average of 3 storms traverse the ocean from the American to the European coasts in that month.

The storms traced over the north Atlantic Ocean for December, 1891, were attended by gales of seasonal severity. Three of the storms traversed the ocean, the tracks being plotted from the Canadian Maritime Provinces to the region north of the British Isles. One of these storms is traced as low area IV; it left the Pacific coast on the 7th, passed north of Newfoundland the night of the 9–10th, was central west of the British Isles on the 13th, and disappeared in the direction of Scandinavia by the 14th. The following is a description of the storms which appeared during the month:

The month opened with low pressure from Newfoundland to